

The Spawning and Early Development of the Atlantic Parrot Fish, *Sparisoma rubripinne*, with Notes on Other Scarid and Labrid Fishes¹

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(Plates I & II; Text-figures 1 & 2)

THE scarid fish *Sparisoma rubripinne* (Pl. I, Fig. 1) was described by Valenciennes from Santo Domingo in 1839. The specific name alludes to the red color of the anal and pelvic fins. More important as a recognition character underwater is the yellow of the caudal peduncle and fin. The rest of the fish is drab, varying from gray to brown or olive. The edges of the scales are darker than the centers, and two pale bands traverse the chin.

Adults of *S. rubripinne* are reef fishes. They appear to occupy shallower water, generally, than most other parrot fishes. When pursued, they sometimes swim into the foaming swirl of waves striking a coral reef or rocky shore. Or they may come to rest upon the bottom where they rapidly assume a mottled color pattern and match the surroundings remarkably well (Longley & Hildebrand, 1941: 216, pl. 28, fig. 2).

This parrot fish is moderately abundant throughout the Caribbean. Breder (1938: 212) referred to it as a West Indian species and gave the continental range as Rio de Janeiro to Florida with stragglers rarely to Massachusetts. Beebe & Tee-Van (1933: 207) listed it as uncommon at Bermuda. Bauchot & Blanc (1961: 61) recorded it from the island of San Thom , apparently the first record of the genus *Sparisoma* from West Africa.

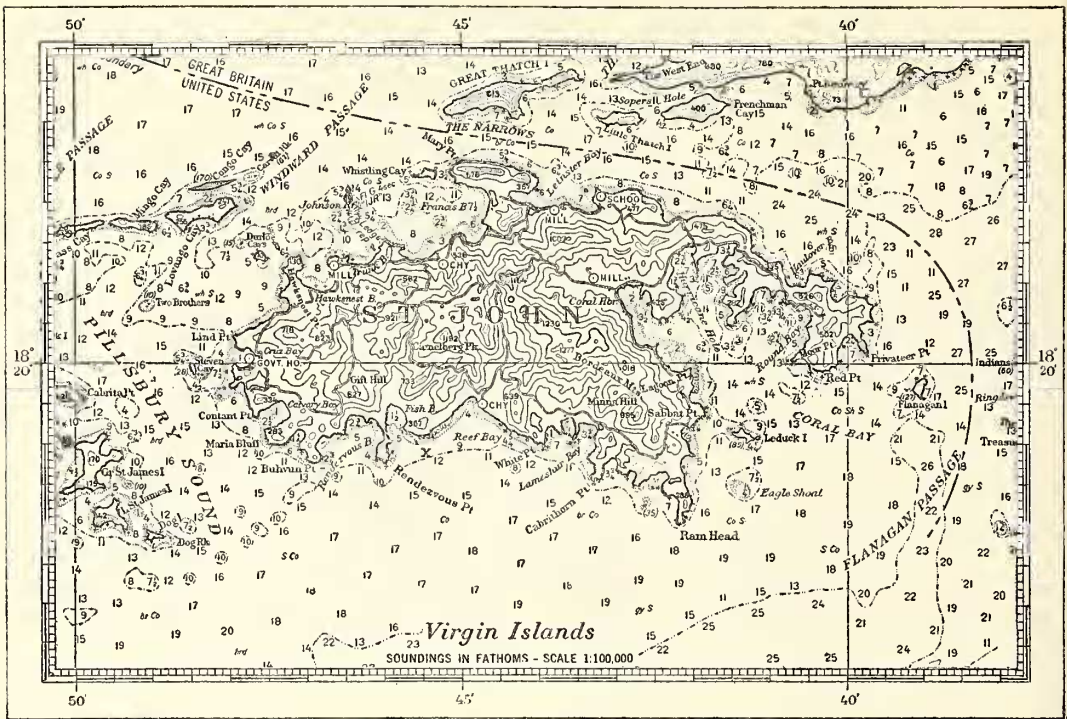
Randall (1962) has presented data on the relatively rapid growth of this and five other West Indian parrot fishes based on tagging studies in the Virgin Islands. Twenty-nine recoveries of tagged *rubripinne* were made, nine of which represented fish at large with tags for

one month or more. These nine, 175 to 266 mm. in standard length when tagged, grew at an average rate of 8.1 mm. per month. All 29 fish were recovered in the vicinity of the original tagging sites.

On April 10, 1960, an aggregation of about 200 identically-colored individuals of *rubripinne* was encountered by the senior author at a depth of 70 feet at the most offshore extension of fringing reef from the west end of Reef Bay, St. John, Virgin Islands (X of Text-fig. 1; see also the chart of the marine environments of St. John in Kumpf & Randall, 1961). The fish were milling at a height of about 8 to 15 feet above the reef front. Since this parrot fish had previously been observed only as individuals or small groups in close association with the bottom where they graze much of the day on benthic plant life, the exposed position of so large an aggregation well off the bottom immediately attracted attention. Continued observation revealed that small groups of fish would dart rapidly upward and spawn above the aggregation. Later, a second pattern of spawning was noted in which a single female *rubripinne* spawned with a larger pastel green fish (Pl. I, Fig. 2) identified from the recent review of the Scaridae (Schultz, 1958) as *Sparisoma axillare* Steindachner. The latter fish, however, is a late-appearing male color phase of *rubripinne*. The "rubripinne" form may be a juvenile, mature female or mature male. Taxonomic considerations of *rubripinne*, including a color plate of both the "rubripinne" and "axillare" phases, are given in another paper (Randall, 1963), along with other examples of sexual dichromatism in parrot fishes.

Longley (in Longley & Hildebrand, 1941: 209) was the first to demonstrate sexual differ-

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TEXT-FIG. 1. Chart of St. John, U.S. Virgin Islands. From U. S. Coast and Geodetic Survey Chart 905. X marks the location off the west end of Reef Bay where most observations were made of spawning *Sparisoma rubripinne*.

ences in the color of a scarid fish (*Sparisoma radians*). More striking were the differences shown by Brock & Yamaguchi (1954) for the Hawaiian species, *Scarus perspicillatus*. Winn & Bardach (1957, 1960), working in Bermuda, linked four differently-colored and differently-named Atlantic species. They injected testosterone into adult females of three of these species and caused them to assume the more colorful male pattern.

It has been presumed that the brighter color of male parrot fish is associated with sexual maturity. The observation of the spawning of like-colored male and female individuals of *rubripinne* necessitates a modification of this concept. The attainment of the "axillare" color phase by the male is not associated with maturity but with the adoption of a new pattern of spawning behavior. Group spawning of males and females of the same color and spawning by pairs in which the sexes are of different hues was also observed for *Scarus croicensis* and for the wrasse *Thalassoma bifasciatum* (brief accounts of these two species follow the discussion of *rubripinne* below). It is expected that many other sexually dichromatic scarid and labrid fishes will be shown to have similar dual patterns of reproductive behavior.

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SPAWNING SEASON

Direct observations of the spawning of *rubripinne* were made on 44 days throughout the period April 10, 1960, to June 30, 1961, at Reef Bay and on three days at a subsequently discovered spawning site off Cabritte Horn Point, also on the southern shore of St. John. Two additional dives were made in October, 1961, and three in April, 1962. Ripe male and female fish were collected in all months of the year. And even when not ripe, the gonads of adult fish were well developed and easily distinguished as ovaries or testes without microscopic examination. Therefore this parrot fish, at least in the Virgin Islands, spawns the year-round. It is possible that spawning is seasonal in regions where there is more variation during the year in water temperature and length of day. Extremes in average monthly sea bottom temperatures in St. John were 26.5 and 29.4°C. (Randall, 1962).

SPAWNING SITES

The particular section of reef at the western end of Reef Bay, where spawning was first seen, is the most southerly projection of the long and well-developed fringing reef of the bay. We believe that the large number of spawning fish seen at this site is a result of a movement of fish from the more inshore portions of this extensive reef to the most offshore part for spawning. Cabritte Horn Point (Cabritthorn Pt.) is a similar area. Fish living on the fringing reef on the west side of the point (extending into Lameshur Bay) or the east side (Grootpan Bay) which follow the reef to its deepest part will end up at the demarkation of reef and sand and coral rubble at a depth of 65 feet off the point. Small groups of *rubripinne*, assembled as if for spawning, have also been observed off Boiling House Point and Yawzi Point in the Lameshur Bay area. Although actual spawning was not observed, it probably occurs off these points too. The sudden appearance of a diver at a spawning site generally causes the cessation of reproductive activity by the parrot fish, and much waiting is usually necessary before spawning is resumed. Large barracuda (*Sphyraena barracuda*) and kingfish (*Scomberomorus cavalla*) sometimes forced the spawning fish to withdraw to the protection of the reef. Schroeder once observed a barracuda strike and capture one of the parrot fish from the aggregation.

On one occasion (April 30, 1961) the spawning of *rubripinne* was seen nearer shore over the reef at Reef Bay. A group of about 30 fish spawned at a depth of 25 feet. Nevertheless the deeper reef fronts appear to be the primary focal points for the reproduction of the species. It would seem advantageous for species with pelagic eggs to spawn in the deeper water off points where currents afford more opportunity for dispersal and there is less likelihood of the eggs and larvae encountering unfavorable conditions.

TIME OF DAY OF SPAWNING

It was soon noted that *S. rubripinne* was not present on the deep reef off Reef Bay except during afternoon hours when spawning occurred. Dives made between 7 a.m. and 11 a.m. failed to reveal any of the parrot fish at the 70-foot depth. Small groups of fish arrived from inshore to the reef front beginning no earlier than 11 a.m., and sometimes as late as about 1:30 p.m. The earliest that spawning was seen to commence was 11:25 a.m. and the latest 1:45 p.m. It continued through the afternoon until about 5 to 5:40 p.m., when the fish left in small groups and swam toward shore. It is not known whether fish arriv-

ing in the first groups remain at the spawning site all afternoon. The number of fish increases as the afternoon progresses, giving the impression that earlier arrivals remain; however there could merely be more new fish coming to the site than fish departing from it until the end of the day.

SEX RATIO

One hundred and nine fish were speared by the senior author from spawning aggregations on 15 different dives when no distinction was made in behavior between males and females. Eighty-five of these fish (77%) were running ripe males, ranging in standard length from 208 to 283 mm. and averaging 246.4 mm. The remaining 24 fish were ripe females from 217 to 269 mm. in standard length and averaging 246.7 mm. In order to ascertain if this represented the sex ratio of adult fish of the "rubripinne" phase for the entire population, individual fish were speared in their normal inshore habitat during morning hours before 11 a.m. and in the afternoon after 1 p.m. Of 64 mature fish speared in the morning, 33 were females ranging from 220 to 301 mm. in standard length (average 236.5 mm.) and the remaining 31 were males 194 to 263 mm. in standard length (average 226.1 mm.). Sixty-four fish were speared in the afternoon, of which 43 (67.2%) were females 210 to 278 mm. in standard length (average 238.0 mm.). Thus it is apparent that the true sex ratio approximates 50-50 and the preponderance of males in the spawning groups is a result of movement of more males from inshore waters during afternoon hours.

Twenty-nine *rubripinne* in the "axillare" phase were speared, and all were males. These ranged in size from 232 to 325 mm. in standard length, and averaged 283.2 mm., thus being larger than the males and females in the "rubripinne" phase. Among adult fish, the "axillare" form is notably less common than the "rubripinne" phase. Based on collections and underwater counts in St. John, there appears in most areas to be about 20 to 30 times more "rubripinne" than "axillare." In one locality, the rough water off Ram Head, St. John (the southernmost point of the island), a region where the water deepens rapidly, "axillare" was noted on one dive to be at least as numerous as adult "rubripinne."

SIZE AT MATURITY

As indicated above, spawning female *rubripinne* as small as 220 mm. in standard length and males as small as 194 mm. were collected. Mature females (ova may easily be seen with the naked eye) have been taken in St. John as small as 203 mm. and immature female fish as large as 220 mm.

SPAWNING BEHAVIOR OF AGGREGATIONS

The first indication of spawning is the increased activity of small groups of parrot fish within the large milling aggregation. From four to about thirteen fish begin to move as a unit within the large group, rise still higher in the water, and change direction frequently. Immediately prior to the spawning movement, the fish in a group incline their bodies upward. After a brief hesitation they shoot upward with a great burst of speed, utilizing their caudal fins (previously they swam by pectoral fin movement alone). The fish sometimes move directly upward but more often diagonally upward. These spawning runs carry the fish an estimated 7 to 12 feet from the starting position. Spawning occurs at the peak of the upward movement where a white cloud indicates the liberation of milt. The descent to the rest of the school is characterized by a dispersal and is not as rapid as the ascent, particularly as the fish approach the rest of the large group. The spawning runs were estimated to require as little as 2 seconds. This estimate was confirmed later when sixteen-millimeter motion pictures were taken of the spawning of *rubripinne* at 24 frames per second. Ten spawning runs in which from 4 to 11 fish participated were photographed (selected frames from two sequences are reproduced herein as Plate II). The runs took from 43 to 63 frames of movie film, hence required from 1.8 to 2.6 seconds. The motion picture film shows even better than direct observation the amazing coordination of the fish on the spawning runs. Nearly all release their eggs and sperm at the same time and place in spite of the great rapidity of movement.

Not infrequently there are false starts with one or more individuals "jumping the gun" and rushing a short distance above the group. After such false starts the fish usually reassemble quickly and proceed again. During the upward rush the fish are generally close together but occasional individuals get a late start. If a slow-starting fish fails to catch the group, it swims to the same place to release its gametes. Such a fish is evident in sequence A of Plate II, first appearing in lower right center of frame 12.

A first spawning by a group of fish seems to act as a stimulus for further groups to make reproductive runs, and one run may follow another in fairly rapid succession. At times a second group will spawn in exactly the same place as a first. The white cloud of sperm from the first group, which remains visible for several seconds, seems to act as a point of attraction for the second group.

Spawning is not continuous. There are usually about three to six spawning runs over a period of one to two or three minutes. Then five minutes or more elapses without any such activity. During these interludes the school often comes close to the reef and many of the fish swim to the bottom. Some feed while on the bottom but most appear to rest or swim slowly. Generally there is a haphazard milling and interchange of fish between the bottom and the aggregation for several minutes. Often the entire group moves slowly but directionally across the reef to or slightly beyond the reef front at another place 200 feet or more away where milling again commences, followed ultimately by spawning. When observations were carried out over an entire afternoon, it was noted that there was considerable movement back and forth between the first site and the second. These sites were by no means highly circumscribed, and spawning occurred in intermediate places, including over the reef proper.

As the number of spawning fish increases later in the afternoon a large aggregation often breaks into two or even three groups in which spawning proceeds independently. The groups may reassemble and divide again. The smallest number of fish seen in one aggregation from which spawning occurred was 22.

The preponderance of males in the large spawning aggregation and the high degree of coordination of movement of spawning fish suggest that one fish, perhaps a female, is the lead fish of the small groups and the rest are males. Earlier observation did not confirm this because no fish consistently occupies the foremost position and all seem to change direction more-or-less simultaneously. However, with careful observation, it is usually possible to decide that one fish is guiding the others. Although other fish often precede it, they are above, below or to the side and not directly in front. Two of the lead fish were speared, and both were females.

It is our belief that each small group consists of a single female and from about 3 to 12 males. This is a higher percentage of males than exists in the large aggregation; therefore it seems likely that males take part in the spawning runs more frequently than females. Perhaps a female makes only a single or a few spawning runs in one afternoon. Since there is no apparent difference in morphology or color between the male and female in the "*rubripinne*" phase, a question arises concerning the mode of detection of the female by the male. Perhaps the female exudes a chemical substance which is perceived by the male.

Occasional fish in the small groups quiver their

bodies briefly, without changing their rate of progression, as if in sexual display. Seven of these were speared (April, 1962) and all were males (these fish are not included among those collected for the determination of sex ratio). Usually the fish which twitch their bodies are above and to one side of the lead fish. The lead fish were never observed to quiver.

The swift upward movement leading to spawning and the subsequent withdrawal to the large group below that characterizes the reproduction of *rubripinne* has been observed for other parrot fishes, five species of wrasses and the goatfish *Pseudupeneus maculatus* in the Virgin Islands. It was reported for three species of Indo-Pacific surgeon fishes by Randall (1961). With respect to the surgeon fishes, it was suggested that the sudden upward rush facilitates the expulsion of eggs and sperm because of the expansion of the airbladder from the pressure change. Also the sharp flexing of the bodies of the spawning fish at the peak of the movement probably enhances the release of sex products.

SPAWNING BEHAVIOR OF PAIRS

Usually one or two of the larger green "axillare" form were seen swimming in or near the aggregations of "rubripinne." When swimming among the schools of "rubripinne," the "axillare" phase does not participate in the spawning. On the contrary, it almost seems to be disposed to interfere with it. Individual "rubripinne" are chased and even nipped. Four of the fish chased by "axillare" were speared, and all were males.

After *Scarus croicensis* was observed to spawn both in pairs and aggregations of like color (see below), it was presumed that the "axillare" form would spawn individually with a single "rubripinne" phase female. The chasing of male "rubripinne" in the aggregations seemed consistent with this concept. Many hours were spent observing "axillare." On a few occasions the fish were seen about five feet off the bottom swimming over a "rubripinne"-phase fish which was next to the bottom. The "axillare" form sometimes twitched its body in the same manner as observed by male "rubripinne" in the small groups just prior to spawning. The fish on the bottom did not heed the "axillare" form. One was speared and it was a male. Presumably the "axillare" fish, swimming above "rubripinne," cannot detect male from female. When "axillare" approaches fish in the large aggregations from the rear, it is possible that it detects males by chemoreception and gives chase.

Twice a green form which seemed to be "axillare" was seen to rush upward and spawn with

a drab "rubripinne"-phase fish. These observations were made at the limit of visibility and identifications were not positive. Finally on April 20, 1962, one large "axillare" was seen to spawn with a "rubripinne." This occurred on the 70-foot reef off Reef Bay, St. John. The female fish on the bottom rose in the water several feet to join the "axillare" male above. There was a brief pause as their bodies were tilted upward, and then they swam rapidly upward for about 5 to 6 feet, released eggs and sperm at the uppermost point as they turned sharply and then swam to the bottom.

Certainly most of the reproduction of this species takes place from the large aggregations of like-colored fish. The reproductive potential of a fish is greatly increased when large groups assemble at specific sites for spawning. Possibly the spawning by individual pairs of fish of different color is the basic reproductive pattern for parrot fishes. Aggregate spawning may be a secondary development associated with the attainment of sexual maturity of males before a color change takes place.

OBSERVATIONS ON THE SPAWNING OF *Scarus croicensis* AND OTHER PARROT FISHES

Dual spawning behavior has also been observed for *Scarus croicensis* Bloch, a relatively small species (standard length probably not exceeding 200 mm.) in which the drab phase is striped with dark brown and white, and the brightly colored, usually larger male phase (long considered a distinct species, *S. punctulatus* Valenciennes) is predominately blue-green and pinkish orange. It is often confused with *Scarus taeniopterus* Desmarest in Valenciennes (Randall, 1963).

On August 5, 1960, a green and orange male was observed swimming about six feet above the bottom at the same reef off Reef Bay, St. John, Virgin Islands, where the large aggregations of *Sparisoma rubripinne* were first noted. The male swam rapidly with pectoral fins over a smaller striped-phase fish on the bottom and occasionally vibrated its tail and the posterior part of its body. The striped fish rose slowly in the water and the male above came down slightly to meet it and then both swam very rapidly upward together to spawn about four feet above the starting place. Both were speared; the colorful fish was a 196 mm. ripe male and the drab one a 148 mm. ripe female with spindle-shaped ova as described by Winn & Bardach (1960: 33, pl. 1, fig. 1 C). The same behavior was observed, often repeatedly, on eight other days during the months of February, March, April, June and August.

The observations were not planned and reporting them by month is not intended to indicate a spawning season. The ripe males spend a great deal of time in display well above the bottom. Each male appears to establish a sector over which it swims and from which it drives males of adjacent territories if they come too close.

On March 22, 1961, at Cabritte Horn Point, St. John, at a depth of 65 feet near the reef front a group of about eight *croicensis* in the striped phase were observed to spawn together, starting from just off the bottom and dashing to a peak three to four feet above. A total of seven striped-phase fish were speared from the immediate vicinity, several of which were definitely from the spawning group. Five were ripe males from 135 to 153 mm. in standard length. Two of these, 140 and 153 mm. in length, showed signs of color change to the "punctulatus" form. The upper and lower edges of the caudal fin were becoming blue, and the lobes of the fin were beginning to show a suffusion of orange next to the blue margins. The base of the dorsal was orangish, and the chin was becoming orange and showed a faint blue-gray transverse band. The two females measured 145 and 157 mm. and were ripe.

The limited observations on *croicensis* suggest that the spawning by individual pairs of differently colored fish accounts for most of the reproduction of the species.

Also observed spawning on eight different days in the Virgin Islands was *Sparisoma aurofrenatum* (Valenciennes), in the months of March, April, June and August, mostly in 60 to 70 feet of water. As with *croicensis*, no attempt was made to study the reproduction of this species, and the lack of observations in other months does not imply a lack of spawning at this time. Winn & Bardach (1960: 33) found ripe *aurofrenatum* in Bermuda from June to August and described the spawning from observations made on September 5. They described a rotation of the male and female as the two fish swim upward in the spawning run. We noted this on only one occasion at a depth of 20 feet in St. Croix, when the spawning pair was viewed from the surface directly above. It is possible that the rotation was overlooked when observations were made from the side. We also noted the tendency of males to cruise over relatively large areas and to chase one another. One male chased another at great speed for a distance of more than 30 feet. The fish that was chasing had a striped pattern superimposed on the usual one. At the end of the chase both fish stopped on the bottom about four feet apart, erected their fins and elevated their bodies head-up to a

near vertical position. They maintained this pose for over 20 seconds, both respiring very rapidly, probably from the exertion of the rapid swimming.

On May 30, 1960, a large green male *Sparisoma viride* was seen swimming actively about 10 feet off the bottom at the reef off Reef Bay, St. John, in 70 feet of water. A small female rose from the bottom to meet him, and the two spawned in the same manner as described for pairs of *S. rubripinne*. Both fish were speared. The male was 399 mm. in standard length and weighed 2 pounds 5 ounces, and the female was only 182 mm. in standard length and weighed 7 ounces.

The female and small male phase of this parrot fish, initially described as a different species, *S. abildgaardi* (Bloch), is bright red ventrally and thus more colorful than most female scarids. Winn & Bardach (1947, 1960), with the assistance of Donald S. Erdman and Jorge Rivera of the Institute of Marine Biology, University of Puerto Rico, demonstrated that *abildgaardi* and *viride* are color phases of the same species. Although the green *viride* phase attains a large size, the changeover in color pattern takes place at a relatively short length. Three specimens transforming from the "abildgaardi" to the "viride" form have been collected by the senior author. They range in standard length from 176 to 180 mm.

A large school in the "abildgaardi" phase was once observed swimming slowly over a reef. The presence of so large a group of one color suggests that this species might also spawn in aggregations like *rubripinne*.

On August 23, 1960, a pair of *Scarus vetula* was seen to spawn in only 7 feet of water off St. Croix. Only the latter part of the spawning run was observed; therefore it is not known if the two fish started from the bottom or several feet above it. Neither fish was collected, but one was the lovely blue-green and rose male phase and the other the drab "gnathodus" type. On January 20, 1963, 6 miles south of La Parguera, Puerto Rico, at a depth of 70 feet, a pair of *S. vetula* was again observed to spawn. Only the upward rush of the two differently colored fish was seen, and this near the limit of visibility.

OBSERVATIONS ON THE SPAWNING OF *Thalassoma bifasciatum*

The labrid fish *Thalassoma bifasciatum* (Bloch) is one of the most abundant reef fishes of the tropical western Atlantic. It occurs in several forms which were given different scientific names that persisted long in the literature (Longley,

1914, 1915; Tee-Van, 1932; Longley & Hildebrand, 1941). Most common is the "nitidum" form which has a truncate caudal fin and is yellow with a lengthwise black band on the side of the body. This band may break up into a series of squarish dark blotches, or it may be so faint that the fish seems almost entirely yellow. A usually larger phase (up to about 6 inches total length), on which the valid scientific and common names are based, has a bright blue head and a green body with two broad vertical black bars anteriorly which are separated by a light blue interspace. The caudal fin is deeply lunate, the lobes blackish. The pectorals are tipped with black. Goodrich & Biesinger (1953) investigated the histological basis of the color of the bluehead phase of *Thalassoma bifasciatum*. This phase is always male and is uncommon compared to the "nitidum" form which may be mature female, mature male or immature. After examining the gonads of a series of specimens of *bifasciatum*, Longley (in Longley & Hildebrand, 1941: 197) wrote, "Clearly this is a single sexually dimorphic species, in which the male attains sexual maturity while still displaying that juvenile coloration which the female retains throughout life." Stoll (1955) demonstrated that the color change is under hormonal control. She injected "nitidum"-phase fish with methyl testosterone and produced blue-colored fish in both sexes. The ovarian tissue of the females regressed and testicular tissue containing small reservoirs of mature sperm developed throughout the organ. Ovarian tissue predominated, however, along with an abundance of connective tissue.

In early 1958 at Cat Cay in the Bahamas in less than 6 feet of water the senior author observed the spawning of a group of the yellow "nitidum." The individual fish were only about 50 to 60 mm. in total length, a size so small as to seem immature. Subsequently in the Virgin Islands on 23 different days in 10 different months in all seasons of the year, aggregate spawning by the small fish was noted (observations made one or two days after an initial sighting of spawning were not counted). The fish usually concentrate their activity over prominent rocks or heads of coral. As many as 80 or more were seen milling at one time over a single coral head. Within this aggregation smaller groups of about 5 to 10 or more fish began to swim more rapidly in one direction and then another. As with parrot fishes, there was a sudden upward or diagonally upward movement which resulted in the fish being a maximum of about 2 feet above the rest of the group. A small cloud of white could often be seen, indicating release of sperm.

Observations of the spawning of *Thalassoma bifasciatum* were more-or-less accidental, *i.e.* no dives were made for the primary purpose of observing the reproduction of this wrasse. On some days the reproductive activity was greater than others, and it seemed that these occurred mostly within a period of a few days containing the full moon and to a lesser extent, new moon. Field notes were scanned to tabulate the dates on which spawning was observed, and the nearest time of full or new moon was then noted. Nine of the 23 spawning days, all in different months or years, occurred within two days of full moon and five within two days of new moon. Thus, there is a slight suggestion of two peaks of spawning intensity within a period of one lunar month, one during full moon and one during new moon. Henry Feddern of the Marine Laboratory of the University of Miami is making a study of certain aspects of the biology of *T. bifasciatum*, including analyses of the gonads of large collections of this species. Possibly he will be able to determine whether or not there is any lunar periodicity in the spawning of *bifasciatum*.

Rarely were the large blueheads present in the milling aggregations of the yellow "nitidum," and then they mostly chased individual yellow fish. The bluehead phase was often seen chasing individuals of feeding groups of "nitidum" and effecting a display by fully erecting the dorsal fin, the anterior black spot of which is prominent. Some yellow fish are pursued very ardently and in an aggressive manner. One of these was speared and proved to be a ripe male. Others are followed only briefly. The latter may be females which are not ready to spawn. On only two occasions was spawning by blueheads and yellow phase females observed. After a very short chase the female fish darted upward with the male bluehead and they spawned. A high percentage of the reproduction of *T. bifasciatum* is carried out by monophase fish, thus paralleling the mode of reproduction of *Sparisoma rubripinne*.

Certain wrasses are known which show sex reversal from female to male (Lönnerberg & Gustafson, 1936; Bacci & Razzanti, 1958), a phenomenon more often associated with the Sparidae and Serranidae. The possibility of protogynous hermaphroditism in *Thalassoma bifasciatum* has not been investigated, but presumably will be by Feddern.

Some other species of *Thalassoma* exhibit a common small form of simple and often drab color pattern and a relatively rare large male form complexly and gaudily colored. It is likely

that such species exhibit a dual spawning pattern like *T. bifasciatum*.

Thalassoma ballieui (Vaillant & Sauvage), a drab Hawaiian species, has no large colorful male phase. Possibly such a phase was extant at one time. The monophase *ballieui* may have reproduced in aggregations and the hypothetical colorful male only occasionally with an individual female. One additional step, the complete elimination of the large male form, could occur by the failure of the fish to produce sufficient androgenic hormone to effect the changes in color and morphology. After reading the manuscript of this paper, Dr. C. M. Breder, Jr., suggested that *ballieui* might be given injections of testosterone to see if any changes in color occur.

OBSERVATIONS ON THE SPAWNING OF *Halichoeres* spp.

The reproduction of four species of the labrid genus *Halichoeres* was observed in the Virgin Islands and Puerto Rico: *H. garnoti* on February 17, 1961, and April 5, 1961; *H. bivittatus* on March 11, 1961, and February 10, 1963; *H. maculipinna* on March 17, 1961; and *H. radiatus* on April 20, 1962. Spawning by aggregations of like-colored fish was not seen; all of the fish reproduced as individual pairs. The more colorful males, often twice or more the length of the females, spent a great deal of time pursuing the smaller drab fish of their respective species and in display with erected dorsal fin. The males of the three smaller species scurried just off the bottom over broad areas, chasing every fish of their species they encountered. The usual response of the pursued fish was merely to try to get away. Those that spawned swam upward in close proximity to the males with amazing rapidity a foot or two above the starting position near the bottom, spawning at the peak of the movement. The males then continued their relentless pursuit of other fish. The male *garnoti* and *bivittatus* which were observed to spawn were about 150 mm. in standard length; none was collected. The one male *maculipinna* seen to reproduce was ultimately speared. It measured 109 mm. in standard length. The female with which it spawned was about half its length. The upward movement of their spawning run carried them an estimated 14 inches above the bottom.

The male *H. radiatus* that was seen to spawn had a prominent pale blue bar with dark edges in the middle of the body. It cruised several feet over the female on the bottom. The male was collected with a spear; it measured 322 mm. in standard length.

EARLY DEVELOPMENT OF *Sparisoma rubripinne*

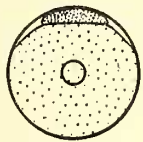
The pelagic, spherical eggs of *Sparisoma rubripinne* were obtained from a fish speared at Reef Bay, St. John, and artificially fertilized from the sperm of males speared at the same time. They were reared in 3-gallon jars at an average temperature of 26° C. up to an age of 6 days, 15 hours. Twelve developmental stages are illustrated in Text-fig. 2.

The fertile egg of the figure measured 0.675 mm. in diameter and its single oil droplet 0.135 mm. The cell division of the blastodisc is rapid, and the 8-cell stage was evident by 1 hour, 20 minutes. The cells are so small by the time the blastula stage is attained (figured at 5 hours, 40 minutes, of development) that they cannot be detected with the use of a dissection microscope. By 14 hours the embryo has begun to elongate over the yolk and segmentation is under way. At 22 hours the lens of the eye is apparent, and melanophores are beginning to appear. Hatching took place in 25 hours. The length immediately following hatching is 1.7 mm.

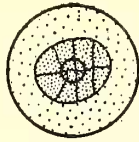
The oil droplet is in an anterior position, and the newly hatched prolarvae float with the cephalic end up. They rise slowly at an average rate of 0.35 mm. per second (based on measurement of the rise of 10 larvae with extremes in rate of 0.15 and 0.61 mm. per second). At this stage they are capable of short swimming movements by rapid fluttering of the tail. Most of these movements are less than 10 mm. in length, and they often follow a spiral path. Usually the larvae execute a turn and swim downward.

At 31.5 hours of development the prolarvae no longer rise in the water and some have already begun to sink very slowly. They are capable of movements as great as 70 mm. About half the time these movements carry them to a higher position. The rest of the time 180° turns are executed, and the little fish reach a lower level than the starting position. For the most part the larvae are still oriented with the head up. Those at the surface lie on their side. In later stages before the appearance of the air bladder, the larvae are oriented with the head down and sink progressively more rapidly as yolk is used up (both yolk and oil droplet are entirely gone by 3 days). Most swimming movements are now characterized by turns which result in the fish being in a higher position in the jar.

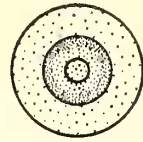
Very few larvae survived to the age of 6 days. The failure to carry development much beyond this stage appeared to be the result of insufficient planktonic food organisms in the jar.



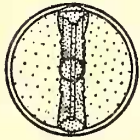
FERTILE EGG



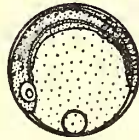
1 HOUR, 20 MINUTES



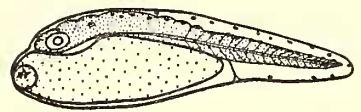
5 HOURS, 40 MINUTES



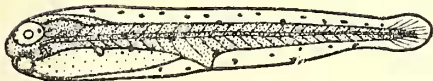
14 HOURS, 30 MINUTES



22 HOURS



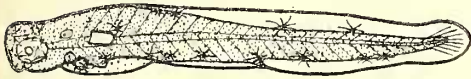
1 DAY, 4 HOURS



1 DAY, 17 HOURS



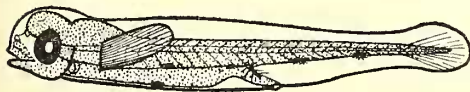
2 DAYS, 2 HOURS



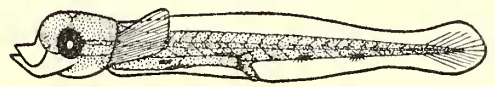
2 DAYS, 16 HOURS



3 DAYS, 3 HOURS



4 DAYS, 16 HOURS



6 DAYS, 15 HOURS

TEXT-FIG. 2. Twelve developmental stages of *Sparisoma rubripinne*. Diameter of egg 0.675 mm. Average temperature during development 26° C.

SUMMARY

The Atlantic parrot fish *Sparisoma rubripinne* was observed reproducing from large aggregations milling several feet above the bottom in 65 to 70 feet of water at the most offshore extensions of fringing reef at St. John, Virgin Islands. Spawning was observed in all months of the year, but only in afternoon hours. All of the spawning fish in the aggregations were identically colored. Of 109 fish speared from the schools, 85 were ripe males and 24 ripe females. The abundance of males appears to be the result of the movement from the normal inshore environment of a greater number of males in the afternoon. The inshore reefs have a preponderance of females in the afternoon but approximately an equal number of both sexes during morning hours.

Spawning within the aggregations is characterized by the detachment of groups of about 4 to 13 fish which swim with great rapidity about 8 feet above the aggregation, release eggs and sperm at the peak of the movement and withdraw to the rest of the school. We believe that a single female serves as the lead fish for each small group of spawning fish.

A second pattern of spawning was observed wherein a single green "axillare"-phase male spawned individually with a "rubripinne"-phase female. The large "axillare" form does not participate in the spawning of groups of "rubripinne"-phase fish. When present in these aggregations, "axillare" merely chases the "rubripinne" form—probably just those of male sex. The bulk of the reproduction of the species occurs from the aggregations of "rubripinne"-phase fish.

The dual pattern of spawning behavior was also noted for *Scarus croicensis* and the wrasse *Thalassoma bifasciatum*. Spawning by individual pairs was observed for *Sparisoma viride*, *S. aurofrenatum*, *Scarus vetula* and four species of the labrid genus *Halichoeres*.

The ova of *Sparisoma rubripinne* were artificially fertilized and development studied to 6 days, 15 hours.

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EXPLANATION OF THE PLATES

PLATE I

- FIG. 1. *Sparisoma rubripinne*. Female, 245 mm. in standard length. St. John, Virgin Islands.
- FIG. 2. "Axillare" phase of *Sparisoma rubripinne*. Male, 255 mm. in standard length. St. John, Virgin Islands.

PLATE II

Selected frames of 16 mm. motion picture film of two spawning sequences (A and B) of *Sparisoma rubripinne* off Reef Bay, St. John, Virgin Islands. Plus X film shot at 24 frames per second with 17 mm. wide-angle lens. Numbers designate frames of each sequence selected for illustration.